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NASA's aircraft needs, as weight has never been an issue for terrestrial solar cells, Del Frate said.

Solar-cell performance plays a prominent role in determining the aircraft's capabilities during the most challenging conditions, at high latitudes in the winter season when the sun, hanging lower on the horizon, couples with short days and long nights. Some laboratory tests show promise in increasing solar-cell efficiency, but related costs of this approach have yet to be determined; it's difficult to tell which solar technology will win out, he added.

Autonomous operation of high-altitude, long-endurance UAV aircraft is another area of technology in which NASA seeks to invest. Researchers seek to build a high level of capability into the vehicles' autonomous systems as a step toward a future in which UAVs are able to complete all their tasks entirely without human intervention, on all kinds of missions.

"You may not see it with the 100-Day Demonstrator, but I can envision a day, when these vehicles reach production, that you might have a single operator monitoring, maybe, a dozen vehicles at a given time. I think that's very likely," Del Frate said. "Each of the vehicles would have programming enabling it to do its mission, change its mission, handle

Just the facts

Visit the NASA Vehicle System program Web site at <http://www.nasa.gov/>.

For more information, contact John Del Frate at (661) 276-3449.

most contingencies, report when there's a problem and be fairly low-maintenance."

NASA researchers will stretch current technological limits to reduce overall costs while allowing missions to thrive in the harsh cold of the stratosphere, an environment that will demand system reliability.

"We'll need materials that have more strength, less weight, and ultraviolet radiation resistance. The stratosphere is a stable environment, but harsh. In addition to ultraviolet radiation, solar-storm activity also penetrates those altitudes and could affect systems on board. The temperature is very low – around minus 70 degrees Fahrenheit."

The challenge doesn't end there.

"No aircraft has ever flown more than 10 days non-stop," he said, referring to the 1986 flight by Scaled Composites' Voyager aircraft. "A single flight is 2,400 hours. That's a lifetime for some aircraft out there. Commercial aircraft have to go in for inspec-

tions every 100 hours. Reliability is an enormous factor.

"To get there, the aircraft will have to go through even colder temperatures and do it all with the reliability of a refrigerator," Del Frate said.

As an intermediate step, NASA is considering development of a 14-Day Demonstrator that would be configured differently from the 100-Day model but which would fly in the same environment and be used to test systems being considered for the longer-duration vehicle. Other benefits of this intermediate step would include giving researchers experience with ground operations, 24/7 communications with the aircraft and general management of the aircraft.

"It would have to be a robust aircraft, an opportunity to learn to crawl before you run," Del Frate said.

The 100-Day Demonstrator will benefit from other Vehicle Systems program projects that will tackle risk reduction and technology development in flight demonstrations. Additional partnering, with the Science mission directorate, is expected in long-term missions conducted under the directorate's auspices. At the earliest stages of planning for such missions, Del Frate said, researchers are talking with scientists at NASA and elsewhere to learn what sensors could be used and what environmental missions in what parts of world are generating the most interest.

Conversely, technology and procedures proven with the 100-Day Demonstrator will have applications in other NASA programs, including UAVs in general and potentially to future planetary vehicles flying in the harsh environments of alien planets.

Use of the stratosphere holds great promise.

"The stratosphere remains a vast, untapped frontier," Del Frate said. "It's like coming to the Americas (was) hundreds of years ago. Today, hardly anybody goes to the stratosphere. Those who do are like the trappers and explorers (of America's frontier era); eventually you want to exploit the stratosphere but with environmentally friendly equipment.

"It's really an enormous piece of real estate up there. I can envision global laser communication between platforms and up to satellites."

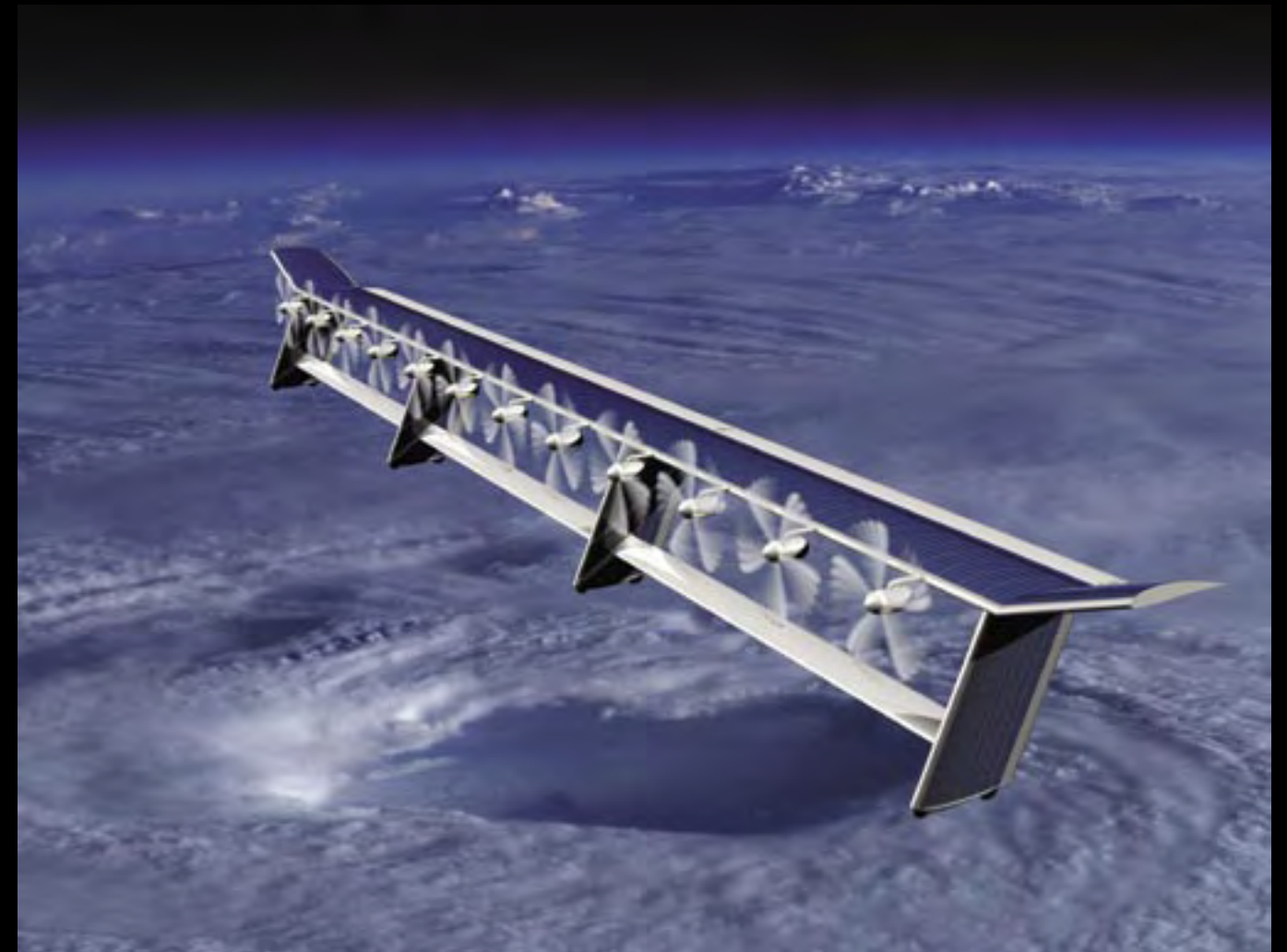
NASA project leaders aim to maximize Agency resources with the 100-Day Demonstrator. Ames, Glenn, Langley and Dryden research centers will contribute to the initiative.

"There are still a lot of things out there to research in this area," said Del Frate. "The potential for these aircraft is huge in this wide-open territory. This is an exciting time for the next generation of engineers. They can help define what that future will be."

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NASA Illustration by Joey Ponthieux

100-Day Demonstrator

Breaking through technology barriers to ready high-altitude, long-endurance aircraft for the missions of today and tomorrow

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Breaking down the technology barriers

By Jay Levine
X-Press Editor

Fleets of flying wings, or airships, fly almost undetected overhead. They're engaged in a variety of missions, from surveying and telecommunications to gathering atmospheric and weather information that has never before been available.

That's the sort of vision researchers hold for the future once NASA's 100-Day Demonstrator takes to the skies beginning in 2011. As technical barriers are removed and the reliability of the uninhabited air vehicle's systems is proven, it will have applications for a wide variety of customers, according to John Del Frate, demonstration manager of NASA's 100-Day Demonstrator UAV program. The 100-Day Demonstrator is a project of NASA's Vehicle Systems program.

"The 100-Day Demonstrator will open up a whole frontier

for doing long-term observation of atmospheric and Earth processes and learning how those processes change over time," he said.

The aircraft will be able to record and measure seasonal variations in the stratosphere and survey entire landmasses with greater persistence than is offered by currently available platforms. Those increased capabilities are key to unlocking the full potential of high-altitude, long-endurance – or HALE – UAV aircraft, Del Frate said.

In addition to NASA's own Science mission directorate, other federal agencies are interested in the promise of these new integrated systems. The Department of Homeland Security wants to monitor long stretches of the U.S. border. The Coast Guard is interested in observing the coastline. And additional capabilities are envisioned for communications, firefighting, completing environmental and agricultural surveys. There is great interest in this class of aircraft at the

National Oceanic and Atmospheric Administration for filling critical gaps in research areas such as weather, climate and ecosystem monitoring.

"We've given a lot of thought and discussion to the use of HALE UAVs as severe storm-weather monitoring platforms, for hurricanes and possibly even tornadoes," Del Frate said.

In addition, technologies derived with the 100-Day Demonstrator also could offer a means of assisting countries all over the globe.

This concept illustration of the 14-Day Demonstrator was developed by Joey Pontbieux, a NCI Information Systems employee at Langley Research Center, Hampton, Va. The aircraft could represent a step toward development of the longer-duration 100-Day Demonstrator.

"We envisioned, from way back, a concept called 'Peacewing,'" Del Frate explained. "The idea came out of the State Department.

"It was viewed that a vehicle like this could be positioned to not only help a community prepare for an unfolding disaster but also remain after the disaster has struck, to help with the emergency response, the restoration of communications and the eventual cleanup – basically, be able to provide an 'eye in the sky' to help responding organizations make the best possible use of their limited resources."

The 100-Day Demonstrator will be a UAV by nature of its missions, he said.

"There will definitely not be a pilot on board. No human has a bladder that can hold out for 100 days," he joked.

Aircraft designers still must decide if the aircraft should feature a fixed-wing design, or be a lighter-than-air ship. Either way, they know it will be powered by the sun. Even a lighter-than-air vehicle – something akin to a blimp

– would require power for its onboard systems.

"(The aircraft) will capture solar power all day long, and whatever you don't need to maintain station and do your mission, you're going to divert that to your onboard energy storage system – capture as much of that as possible, and as efficiently as possible," he said.

Fuel-cell technology is one possibility for powering the aircraft's systems at night. Del Frate explained how such a system would work:

"You start off your mission carrying a certain amount of pure water. During the day, when you have excess electric power generated by the solar array, that power goes into a device called an electrolyzer. The electrolyzer takes pure water and splits the molecule such that you end up with its two constituents in gaseous form – hydrogen and oxygen.

"The two gases are stored on board, under pressure, in at least two different tanks," he continued. "All day long the gases are accumulated. At night you essentially reverse the process. The electrolyzer is shut down and the stored oxygen and hydrogen are recombined through a device called a fuel cell. The fuel cells' byproducts are water, heat and electric power. The heat is dissipated through a heat exchanger or used to keep things warm; water is stored so it can be reused the next day and the electricity powers the vehicle through the night. The next day the cycle starts all over again."



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Photo by Nick Galante

Above, Pathfinder-Plus flies a mission over Hawaii. Upcoming research using a sophisticated atmospheric-turbulence measuring system for a series of low-altitude flights with Pathfinder-Plus will help engineers characterize and model the effects of turbulence on the aerodynamics of lightweight, flexible-structure aircraft such as the 100-Day Demonstrator.

Risk, complexity and cost are all part of the equation for an aircraft that flies for 100 days under solar power, and much remains to be learned despite NASA's experiences with the Helios Prototype aircraft and the family of Aero-Vironment solar wings that included Pathfinder and Pathfinder-Plus. The proposed fuel cell system for the 100-Day Demonstrator, for instance, is not like the one that powered the Helios Prototype. That system consumed hydrogen and air. A fuel cell-based system for storing power has never been flight tested. Such systems have only been ground tested and require continued work to render them more lightweight and reliable.

Taking advantage of the state-of-the-art is one way researchers hope to keep costs down.

In fact, some technologies are maturing so fast they could become usable in time to help reduce cost and weight on the proposed aircraft. As one example, consumer-driven demand for lightweight and powerful batteries for computer laptops and cell phones could lead to those power sources surpassing fuel cells as an option for driving energy storage.

Unfortunately, the same can't be said of solar cells. As yet, there is no similar consumer demand for ultra efficient and lightweight solar cells – devices that drink the sun's energy and convert it to electrical energy. Although the world-wide market for solar cells could easily exceed the market for batteries, consumer market demands would not necessarily match

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